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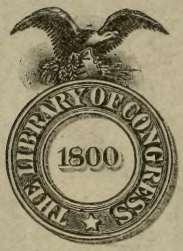

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GEORGE H. ASHLEY, State Geologist

IN COOPERATION WITH THE FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
HENRY S. GRAVES, Forester

CHESTNUT IN TENNESSEE

BY W. W. ASHE
FOREST ASSISTANT, FOREST SERVICE

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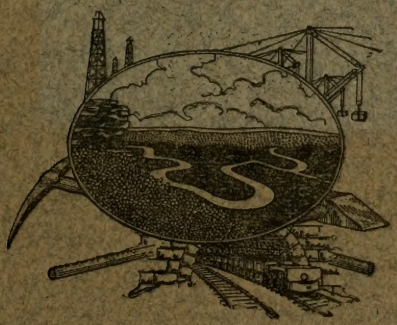

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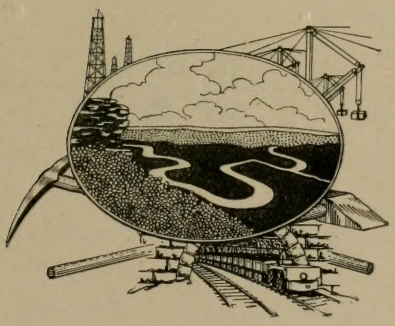

(PUBLISHERS)
BAIRD-WARD PRINTING CO.
NASHVILLE, TENN.
JANUARY 1911

SD 397
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The study upon which this report is based was undertaken by the State Geological Survey in cooperation with the Forest Service, the work being done under the direction of the Office of State Cooperation in the Forest Service and under the local instructions of the Director of the Survey. By the terms of the cooperation agreement the State is authorized to publish the findings of the investigation.

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Chestnut in Tennessee

COMMERCIAL OUTLOOK

Chestnut, because of the extensive and rapidly increasing use of its wood as a source of tanning material, has become one of the most important forest trees of Tennessee. There are now seven tannic extract plants in operation within the State, and all use chestnut wood and bark, though some use in addition, the wood or bark of chestnut oak. To supply these plants more than 50,000 cords of wood are cut yearly in Tennessee with a value of about $187,500 at the shipping points. In addition to the extensive use of the wood for tannin, the census of 1909 reports 71,962,000 feet of chestnut lumber cut in Tennessee, with a mill value of $1,121,888. There were also produced 120,000 sets of heading valued at $5,520, and a large number of staves, ties, and poles valued at not less than $325,000. On a most conservative basis the chestnut is, therefore, worth $1,640,000 annually to the State. With the continued reduction in the available supply of other native tannin materials, the chief of which are hemlock and chestnut oak bark, chestnut must become the chief remaining source of supply, and its use will increase. Since low grade chestnut wood and small-sized pieces, including the bark, can be used for tannin stock, this industry in connection with lumbering, permits the complete utilization of the tree. Chestnut has a comparatively rapid growth; it occupies extensive areas either in pure stands or as the dominant species in mixed stands; it grows on land which has a comparatively low value for agriculture, and reproduces freely by sprouts as well as by seed. These are natural advantages which the tree offers for management. Further, its yield can be largely augmented by protecting the forest from fire, and by thinning young stands; and the value of the forest can be additionally enhanced by systems of cutting designed to produce the most valuable class of commercial products. All these things combine to make the commercial management of chestnut forests a feasible and profitable undertaking.

DISTRIBUTION

Chestnut is commercially important throughout middle and eastern Tennessee and as far west as Perry and Stewart Counties; farther west it is comparatively unimportant. It is most abundant on the slopes of the Unaka and Smoky Ranges embracing the Great Smoky, Unaka, Stone, and Iron Mountains, and on such outlying ranges as the Holston, Frog, and Yellow Mountains. In many places in all of these mountains it forms as much as twenty-five per cent of the forest over tracts several thousand acres in extent. In the Unaka and Smoky Ranges it is locally most abundant on elevated benches of the north and west slopes and on the crests of northern spurs, between altitudes of 1,800 and 3,500 feet. In such situations it may occur pure or nearly pure over areas as large as 100 acres. Between the Unakas and the Cumberland Plateau chestnut forms less than 15 per cent of the timber. Here it is largely confined to hollows and north slopes, and pure stands rarely occupy more than a few acres. On the valley lands, irrespective of soil, it constitutes less than 5 per cent of the forest. It is common on the slopes of the Cumberland tableland, especially on the sandstone soils which have a sufficient depth and are not too rocky; in such situations it forms a large portion of the forest. Chestnut is almost entirely absent, however, on the thin-soiled and stony portions of the tableland, especially near the southern end. In Claiborne, Campbell, Anderson, Morgan, and Cumberland Counties it forms possibly 15 per cent of the timber.

Chestnut constitutes only a small proportion of the forests of the Central Basin, but is one of the chief trees of the Highland Rim. In portions of Hickman County, which occupies a typical situation on the western part of the Highland Rim, 10 per cent of the forest aggregating several thousand acres, consists of chestnut. On the sandier soils of the Highland Rim chestnut comprises up to 20 per cent of the forest on the better sites.

SILVICAL CHARACTERISTICS

Soil and Moisture Requirements:

Chestnut requires for its best growth, deep, moist loams or sandy loams. The soils on which it grows must be of considerable depth to permit the penetration of its ample, deeply ramifying roots, and must be moderately supplied with moisture in the subsoil, but well drained on the surface. It seldom grows on clay

soils, and practically never on limestone soils. On clay soils it grows only where the surface of the land is sufficiently rolling to insure surface drainage, and even then it forms only a small proportion of the forest growth. It makes excellent growth on highly acid soils where it is frequently associated with rhododendron (laurel) on north slopes, or with kalmia (ivy) on west slopes, but it also grows in pure stands. Although less exacting than yellow poplar, walnut or ash, in respect to depth of soil and amount and uniformity of moisture supply, it is more exacting than white oak, by which it is replaced on the drier soils, even where there is considerable depth. On the thoroughly drained sandy or gravelly soils it gives way on cool slopes to white pine, and on somewhat stiffer soils to scarlet oak, especially at middle elevations, and to black oak at lower elevations.

While chestnut is exacting in regard to depth and porosity of soil, and makes moderate demands upon soil moisture, it does not require either a sweet or a fertile soil. Unlike poplar, basswood, and ash, it will grow thriftily upon sandy soils with a subsoil deficient in lime as well as potash, and in addition to its capacity for germinating and growing on the peaty soil of the rhadodendron (laurel) thickets, it does well also on soils with scant humus cover. In these respects it is one of the least exacting of the hardwoods. Of species which require a deep soil, it is intermediate between species like yellow poplar, ash, and walnut, which require considerable soil fertility and the less exacting white and short leaf pines.

As a rule, especially at altitudes between 1,000 and 3,000 feet, chestnut occupies soils which are too acid and sandy to be of high agricultural value unless limed. On the other hand, the soils within these altitudes which are more uniformly moist in the subsoil and are neutral or only slightly acid, such as are occupied by yellow poplar, walnut and locust, are regarded as well suited for farming purposes. At altitudes below 1,000 feet, the soils usually occupied by shortleaf pine, black oak, and hickory, are also considered superior for general farming purposes, to those occupied by chestnut. Above 3,000 feet altitude much of the soil occupied by chestnut is regarded as of good quality for pasture land, if set in redtop (herds) grass, which will grow on more acid soils than will clover and bluegrass.

Temperature and Light

Chestnut is adapted to a wide range of climatic conditions. It flourishes from an altitude of less than 500 feet elevation in southwestern Tennessee, where the average annual temperature is 59 degrees Fahrenheit (the mean of the summer maxima 89 degrees, and the winter minimum seldom as low as zero), to elevations of more than 5,500 feet along the Smoky and Unaka Mountain ranges, where the average annual temperature is below 50 degrees (the mean of the summer maxima not more than 80 degrees, and the winter minimum frequently 30 degrees below zero). Its best growth, however, is on moderately cool sites, such as shady slopes, coves, and elevated benches of the eastern mountains between 1,000 and 3,000 feet in altitude. Here it not only attains its maximum dimensions, but is numerically more abundant, occupying large areas to the practical exclusion of other species. Rainfall has but little effect on its distribution, since Tennessee has a rainfall which is seldom below 40 inches a year, with an equable seasonal distribution.

Reproduction

For seedling reproduction, chestnut requires only a limited amount of light. The seedlings will persist for many years under the shade of old trees, and when twenty to thirty years old may not exceed 15 feet in height and 3 inches in diameter. As a rule, when the large trees which are overtopping these suppressed seedlings are cut, the seedlings respond quickly to the increased light and make accelerated growth. If suppressed for a great many years, however, the seedlings either die or lose their power of rapidly recuperating when eventually favored by more light. Even though they continue to live, they ultimately develop into slow-growing specimens similar to the large trees which form the present old forest. Although sprouts will grow for a few years under poor light, they ultimately require more light than seedlings, and their best development can take place only under full light. When single scattered trees are cut in a stand of normal density there is frequently insufficient light for the sprouts, which die after a few years.

Production of Seed.—Chestnut bears seed or mast abundantly at intervals of a few years. In intervening years the seed crop is lighter, but seldom entirely wanting. The flowers appear in midsummer, too late to be killed by frost, but rainy weather, during

the pollination period, may prevent the setting of the fruit and curtail the crop of nuts. A heavy mast year is usually followed by one of small mast. Even though large quantities of nuts are collected for sale, enough are left on the ground to insure abundant reproduction; these, however, are often eaten by hogs, or burned, and small seedlings that may get started are destroyed by fires and by cattle.

Seedling Reproduction.—The sprouting capacity of chestnut is much more important to its regeneration than its ability to reproduce by seed. Sprouts can be relied upon for reproduction in pure stands or in large groups, or when chestnut is in mixture with other sprout species and is managed on a short rotation. It is necessary, however, to supplement sprouts with seedlings in order to make up for those stumps, whose sprouting power has ceased. Where large timber is desired, as when chestnut is to be grown with oak or poplar for lumber purposes, seedlings are more desirable than sprouts. One-half to two-thirds of full light is most favorable to germination. If the nuts are too exposed they may dry out in the spring before the young root is thoroughly fixed in the soil. It is desirable that nuts lying on the ground in the forest be lightly covered during the winter, not only to keep the kernel moist and in condition to germinate, but to bring it in direct contact with the soil to facilitate rooting. To accomplish this the nuts might be planted or lumbering operations carried on during a season which promises a good mast year; or pigs might be turned in temporarily before the nuts fall. Under ordinary conditions, when nuts are collected for market, the leaves and litter are sufficiently disturbed by the nut gatherers to cover a large number of nuts; and many seedlings are thus assured, unless the nuts left are subsequently destroyed by swine, or the seedlings killed by fire.

Sprouting.—Most vigorous sprouting is obtained from stumps of trees cut in spring, early summer, or late in winter; least vigorous sprouting is secured from trees cut during August and September. Most sprouts appear either immediately at the root collar or just above the ground, and as a rule from partially independent root systems. It is exceptional for sprouts to develop near the tops of stumps. Such sprouts seldom make large and thrifty trees, and since they cannot form an independent root system, they frequently break from the parent stump as they become large and the stump is weakened by decay. Chestnut does not sucker.

The sprouting capacity of chestnut is far superior to that of any other important hardwood growing in Tennessee, and it is exceptional when an unburned stump fails to sprout. On the north slope of Roan Mountain, above Burbank, at an altitude of about 3,000 feet, 99 per cent of stumps of trees 3 to 5 feet in diameter, and varying in age from 150 to 300 years, sprouted, and the sprouts from most of the stumps were both numerous and vigorous. In such a situation chestnut is probably at its best. Several vigorous stands were seen which were composed of the second set of stump sprouts. Stumps should be cut low and obliquely, and the fertility of the soil maintained by preserving the humus. Where this is done and the trees are protected from fire, it is probable that many successions of sprouts can be grown from the same roots before their vigor is exhausted or even seriously impaired. The period of sustained vigor depends on the age at which the successive crops of sprouts are cut, and, to some extent, upon the season of the year.

Root System

The chestnut seedling has a central tap-root and long lateral, fibrous roots and rootlets. Early in life this tap-root divides into many vertical roots, above which are numerous widely ramifying laterals that lie from 6 to 8 inches below the surface of the ground. In mature trees the roots frequently descend to a depth of 4 or 5 feet. Such a root system firmly anchors the tree and renders it extremely wind-firm.

Diseases and Defects.—Until past the pole stage, chestnut suffers severely from fire because of its thin bark. Sprout trees not only have thinner bark, but are likely to be injured through the burning of the old stumps. Since the sprout stands are those left after lumbering, they have been frequently burned, and the trees are either hollow or defective at the base, although the fire scars may have healed over so that there is no external mark.

In addition to plainly evident physical defects, the exposure of wood following the killing of the bark by fire affords an entrance to destructive insects. The most important of these are the chestnut timber worm* and the two-lined chestnut borer.** The chest-

* For information on the chestnut timber worm, see Circular 126 of the United States Bureau of Entomology, "Insect Injuries to the Wood of Living Trees," by A. D. Hopkins.

** For information on the two-lined chestnut borer, see "Injuries to Forest Trees by Flat-Headed Borers," by H. E. Burke, Yearbook, United States Department of Agriculture, 1909.

nut timber worm causes the common defect known as "wormy chestnut," a defect which greatly reduces the value of much otherwise high grade timber. The two-lined borer kills living trees by girdling them by mining beneath the bark. This pest causes the death of many trees, sound ones as well as those injured by fire.

For many years the chestnut on the lower mountains in the southeastern portion of the State has been dying out, a few trees at a time. Examples of this were noted on the English Mountains, Gray Knobs, Chilhowie Mountain, Stars, Bear, Frog, and Red Mountains. Some of these are killed by the two-lined chestnut borer, but while this decline is in part due to the ravages of the borer, it seems to be due more to excessive burning and to the consequent destruction of humus and impoverishment of the soil. Trees in hollows, on cool north slopes and on land where a moderately dense shade and soil cover exist have not been affected. The remedy for the trouble would seem to be to stop fires, to permit humus to accumulate, and to let the young timber grow up thick enough to shade the soil. The dying off of the trees is certainly not due to the chestnut bark disease (diaporthe parasitica), a very destructive parasitic malady from Virginia to Southern New England, no evidence of which was seen in Tennessee.

Chestnut is seldom thrown by the wind, and the stem rarely breaks unless hollowed at the base by fire. The leaders are sometimes broken by sleet and icestorms, and large branches torn away by windstorms.

Forest Types and Associated Trees

Chestnut enters largely into the composition of five well-marked forest types:

(1) Pure chestnut type with less than one-third of other species.

(2) Lower cove type, with yellow poplar, oaks, basswood (or linn), ash and locust.

(3) Upper cove type, with hemlock, birch, hard maple, beech, ash, and basswood.

(4) Chestnut oak and chestnut type, frequently with scrub pine.

(5) Mixed oak and chestnut type, frequently with yellow pine and sourwood.

Of these five, two are cove types, the upper and lower coves; one, pure chestnut, is a north slope type; and two are ridge or south slope types. These topographic divisions are arbitrary and can be applied only roughly, since topography is but one factor influencing drainage, depth of soil, and temperature, and, consequently, the distribution and local abundance of chestnut. On the north and west slopes chestnut is at its optimum. The upper cove marks the minimum temperature it will endure; in the chestnut oak type it reaches its limit so far as shallowness of soil is concerned, while in the mixed oak type it approaches its minimum limits of soil moisture and compactness of soil.

The proportion of chestnut in the mixed types may amount to as much as 65 per cent or as little as 15 per cent, depending upon conditions of soil, drainage, or climate. In each type, chestnut has a different rate of growth, and the system of cutting must be modified for each to obtain the maximum returns and leave the forest in the best shape for growth and for future cuttings.

Growth of Individual Trees

The growth and yield of chestnut vary greatly according to the situation. Three qualities of situation have been recognized: The first includes the lower cove type and that part of the pure chestnut type, where, on the lower slopes, there are the most rapid-growing stands; the second, or average quality includes the greater portion of the pure chestnut type and some of the stands in both the chestnut oak and chestnut type, and the upper cove type; the third, or poorest quality, includes the mixed oak and chestnut type, and the greater portion of the chestnut oak and chestnut type.

Table 1 shows the rate of height growth of the dominant or tallest trees in stands of sprout chestnut for each of these three classes.

Table No. 1: Growth in height of dominant trees in sprout chestnut stands, based on 117 plats on different sites.

Age—Years	First Quality. Height of Trees	First Quality. Growth in height during preceding decade	Second Quality. Height of Trees	Second Quality. Growth in height during preceding decade	Third Quality. Height of Trees	Third Quality. Growth in height during preceding decade
	Feet.				Feet.	Feet
5	18	..	15	..	12	..
10	33	33	27	27	22	22
15	45	..	37	..	30	..
20	55	22	45	18	36	14
25	64	..	52	..	41	..
30	71	16	58	13	46	10
35	78	..	63	..	49	..
40	84	13	68	10	52	6
45	88	..	71	..	55	..
50	92	8	75	7	57	5
55	96	..	77	..	59	..
60	98	6	80	5	61	4
65	101	..	82	..	63	..
70	103	5	84	4	64	3
75	105	..	85	..	65	..
80	107	4	87	3	66	2

As the table shows, the rate of height growth decreases rapidly as the trees become older. In all qualities more than one-half of the total height growth of dominant trees is made by the twentieth year. The rate of height growth decreases to less than one foot a year by the forty-fifth year in first quality stands; by the fortieth year in second quality stands, and by the thirtieth year in those of third quality. Beyond the seventieth year in all qualities the annual height growth is inconsiderable. In most trees the length of the stem has been definitely fixed before the sixtieth year by its division into branches. Its clear length at this age varies in dominant trees from about 60 feet in first quality stands to 45 feet in third quality. Although the trees continue to grow slowly in height as long as they are alive, the clear length can extend only by the loss of lower branches.

Table 2 shows the growth in diameter of trees of each of the three classes in unthinned, even-aged stands.

Table 2: Growth in diameter of sprout chestnut stands; time required to grow one inch in diameter. Based on 117 sample plots.

Diameter, breast-high	Quality I.		Quality II.		Quality III.	
	Age—	Time to grow 1 inch in diameter	Age—	Time to grow 1 inch in diameter	Age—	Time to grow 1 inch in diameter
Inches	Years	Years	Years	Years	Years	Years
10	26	..	33	..	40	..
11	31	5	39	6	48	8
12	36	5	46	7	59	11
13	41	5	53	7	76	16
14	47	6	61	8	..	..
15	53	6	71	10	..	..
16	59	6	83	12	..	..
17	66	7	..	..	..	..
18	73	7	..	..	..	..
19	81	8	..	..	..	..

The rate of diameter growth decreases uninterruptedly after the first few decades. In stands of the first quality during the first decade it takes only three years to grow an inch; by the fiftieth year it takes six years.

Management.

By the management of a forest is meant the use of a definite system of protection and cutting which seeks to perpetuate it and to increase its productive value. Protection may consist in preventing fires and overgrazing, controlling insect attacks or sparing the young growth during lumbering. A stand may be perpetuated by cutting so as to obtain sprouts or seedlings; it may be cut at a period to develop its maximum yield; it may be thinned to accelerate its growth, or to produce material most suitable for special uses. The same methods of management are not applicable to all conditions.

Chestnut is a large component of several mixed types of forest, although it also forms pure stands. It is found in extensive even-aged stands of second growth, as well as in uneven-aged, old forests; it has a slow rate of growth on poor soils, and on better situations its growth is rapid. Some of it is still quite inaccessible, so that only the large timber is merchantable; other stands are close to market, which makes possible a much more

complete utilization. The wood is extensively cut for special uses. Under such a great variety of conditions it is impossible to apply a uniform system of management, and a special system must be developed for each class of forest, if the best results are to be obtained.

The important classes of chestnut forests in Tennessee are:

(1) Uneven-aged stands, consisting mainly of old timber, in which large-sized, overmature, and defective trees often predominate. Most of the old timber is in mixed stands, though there are some pure stands.

(2) Even-aged, second-growth stands, either pure or mixed.

These classes can again be classified according to accessibility; some tracts are near railroads, or connected with farms, or otherwise so situated that close utilization and intensive management is possible; others are distant from shipping points, or cover large areas of rough land, where close utilization at present is not possible.

Forest management of the chestnut in the forests of Tennessee should aim:

(1) To foster chestnut and pine in the mixed stands on the poorer sites at the expense of the slower-growing chestnut oak and white oak.

(2) To get more seedlings of ash, poplar, and red oak in the mixed stands in the hollows, since these species sprout only sparingly, while chestnut will do so abundantly. White pine, also, should be encouraged where it is present. Seedling reproduction of chestnut should be encouraged in the hollows, since seedlings make larger trees than sprouts do.

(3) To maintain on chestnut soils pure sprout stands of chestnut reinforced by seedlings of this species, together with chestnut oak and red oak.

This scheme is based on the supposition that the destructive chestnut bark disease will not reach Tennessee. In the event that it does, cuttings should be made so as to increase the amount of white pine and poplar in the cove type, and the amount of pine on chestnut lands having southern exposures. If the pure chestnut forests are destroyed by this disease, it will be necessary either to plant other species in order to re-establish remunerative forests, or to rely on the slower means of natural reforestation to establish a new growth of other species.

PROTECTION.

Young chestnut is so subject to fire damage that it is of first importance to protect young stands. Old timber with thicker bark is less injured, though it cannot be burned without some injury. While the protection of large tracts is difficult and costly, thick stands and heavy yields of sound timber cannot be obtained unless fires are prevented. There is a striking contrast in the condition of the young timber on repeatedly burned coaled-over land, and the same class of timber in farmers' woodlots which have had few, or no fires. The yield of the burned stands is seldom two-thirds that of protected stands, and the timber is of inferior quality.

Posting the forest fire laws of the State, co-operation with adjoining land owners, and regulating of nut gathering and grazing, all these will help to solve the fire problem. Assistance in fighting fires should be required for the privilege of gathering nuts or pasturing cattle. On large tracts it is possible to maintain a patrol, but it is seldom practicable to establish cleared fire lines. A patrol would undoubtedly be the best manner of protecting recently cut-over land and young timber. Fire guards would be required only during the dry and windy weather, at which times arrangements should be made for securing help promptly when needed. Small tracts, particularly those connected with farms, are more easily protected. Fires are discovered earlier, before they have made great headway, and as a rule assistance for fighting them can more readily be secured. In fighting fire, young timber should be given first consideration, since it is more easily damaged. When clean cutting or heavy culling is practiced, especially summer cutting, it may be necessary to pile and burn slash. This may not be necessary after moderate culling, especially if the trees are not in foliage, or if the tops are closely utilized for extract wood. As a rule it is desirable if hemlock or pine are mixed with chestnut and are cut with it.

Land in process of restocking either by sprouts or seedlings should never be pastured. After it is restocked and the top shoots of the young trees have grown out of reach of stock, limited pasturage can be permitted as in old stands. In any case, the number of cattle grazed should be carefully regulated, especially on recently cut-over land, so that no damage will result.

Improvement Cuttings.

Improvement cuttings are made for the purpose of removing defective trees, either old or young, and eliminating species of low value. The object in making them is to obtain a stand formed entirely of sound trees of desirable species. As a rule, they can be conducted without cost only where there is a market for material for low grade or small dimensions, and thus they are practically restricted to forests connected with farms or to those near towns, shipping points, and tannic acid extract plants.

In old timber they should remove spreading trees which are overtopping vigorous thickets of young growth, and should reduce the number of seed-bearing trees of slow-growing or low grade species, such as black gum, red maple, beech, and white oak. In second-growth stands they should eliminate trees of slow-growing species, individuals with large overtopping crowns and trees with very crooked or short, forked stems, or sound trees of inferior species should be removed. Small poplar may be cut for pulpwood, and chestnut, and chestnut oak for tannic acid extract works. On the Cumberland tableland, there is a demand for mine props; near towns and on farms fuel affords an excellent opportunity for disposing of the products of improvement cuttings.

Thinnings.

The object of thinnings is to accelerate growth. Consequently they are of value only to young stands in which the trees will readily respond to them. The smaller and less promising trees, even of chestnut and other desirable species, as well as those of undesirable species, are removed in successive cuttings, leaving a smaller number of very vigorous, well-spaced stems from which are selected the trees that are to form the ultimate mature stand. All cuttings are for the benefit of these select trees, and are made at frequent intervals to prevent any check in their rate of growth. The prolonged struggle between competing trees is thus prevented by greatly reducing the number of stems per acre. The individual trees of the mature thinned stand are probably no taller than those in unthinned stands, but they have so much larger diameters that the yield of merchantable timber is greatly augmented.

Thinnings should begin between the fifteenth and thirtieth year, according to the rapidity of growth, size of trees, and density of the stand. Sprout stands, because of their more vigorous growth

during the first few decades, can be thinned earlier than seedling stands. The interval between thinnings should vary from five to ten years, depending upon the rate of growth of the trees and the rapidity with which the crown cover becomes filled. As a rule, frequent light thinnings give better results than heavy ones at long intervals. Trees should be removed evenly through the stand, and large clusters of sprouts should be well thinned. By repeating the thinnings it is possible to maintain practically the same rate of diameter increase for a long period and to prevent the progressive decline which takes place in close, unthinned stands. (Table 2).

Thinnings are seldom profitable unless the wood that is removed can be used, or can be sold for enough to cover the cost. Early thinnings will yield only small wood suitable for fence posts or cordwood. Later thinnings will yield some ties and poles, particularly when the stand is being held for large sized sawtimber.

In order to cut trees to best advantage into hewn ties or into poles, it is necessary to maintain sufficient crowding to prevent the stems from being too tapering and to cut before the butts become too large. In the production of sawtimber it is desirable to obtain the largest diameters. For this reason thinnings to accelerate diameter growth become of even greater importance in providing sawtimber than in stands intended for poles and hewn ties. Thinnings should begin earlier and should be heavier than in stands managed for ties and poles.

It is often advisable to thin the sprouts around large stumps. This can be done during the first winter by breaking off the smaller ones, and leaving vigorous sprouts about one foot apart around the stump.

Comparative Yield of Thinned and Unthinned Stands—A comparison of the thinned and unthinned plots in Table 3 shows the actual results in increasing the merchantable volume of stands even by a thinning which was unsystematic. Had the thinning been systematic, the yield would undoubtedly have been higher, and if these two thinned stands had been removed in two cuttings, made at intervals of from 10 to 15 years, it is probable that their yield could have been increased to 25,000 board feet, or that more than 700 sawed ties 7x7 inches and 8 feet long could have been obtained per acre.

Table 3: Number of trees and yield in lumber or ties per acre, of unthinned and thinned stands in similar situations.

	Unthinned Stands.		Yield Per Acre.	
Age—	Trees under 10 inches	Trees 10 inches and over	Lumber—	Ties—
Years	No.	No.	Bd. feet	Number ...
45	220	110	4,220	158
56	184	116	7,980	178

	Thinned Stands.		Yield Per Acre.	
Age—	Trees under 10 inches	Trees 10 inches and over	Lumber—	Ties—
Years	No.	No.	Bd. feet	Number
47	84	148	18,800	555
59	52	132	18,728	553

Clean Cutting and Culling—A comparison of even-aged, second-growth stands which have followed clean cutting for charcoal, with second-growth stands of mixed age which have followed cullings, shows the straightest and thriftiest timber on the areas which were clean cut. The competition between trees of the same height on the clean-cut lands is mutually beneficial, resulting in long, straight stems with low taper. In the mixed-aged stands, on the other hand, there are many trees with short, crooked stems and long, wide-spreading crowns, the result of a long period of suppression.

While clean cutting is by no means possible at the present time in the great majority of lumbering operations, it is the ideal method of cutting chestnut, and should be approximated whenever the market will justify it, and when the cut-over land can be protected from fire. When the land has not been grazed and there have been no fires there will invariably be found beneath the old trees an abundance of small seedling chestnuts. This will often obviate the neces-

sity of leaving seed trees of this species in those places where it is necessary to restock with seedlings.

Culling consists in cutting the larger trees and leaving the smaller ones to grow. Its practice is based on the theory that small trees growing near or beneath large trees will recuperate after the cutting of the larger trees and make accelerated growth. This is by no means invariably the case, and when such small trees have passed through a protected period of suppression their rate of growth is permanently impaired. If suppression is not of too long duration—more than 35 years—and if the trees are growing in good soil, they will recover. Their rate of height growth, however, will not be so rapid and their rate of diameter growth will seldom equal that of trees which have grown thriftily from the first. Culling must be relied upon chiefly in cutting forests which can not be thinned, and where there is no market for small wood. It enables moderate cuttings of large timber to be made at comparatively short intervals—15 to 25 years—but it fails to develop the maximum increment. It is suited particularly to seedling stands, since the partial light is unfavorable for the growth of sprouts, but very favorable for the early growth of seedlings. It is the method which must be used in managing a great portion of the mountain forests of large and old chestnut which are cut to a diameter limit. It is desirable to fix a diameter limit, but this, however, should not always be closely adhered to. In some cases it should be used in the nature of a general guide to the cutting limit. Where only sawtimber can be taken, and many large, unsound trees are left, a diameter limit for chestnut of 18 inches is not too high. When poles and ties can be cut the limit can be lowered to 14 inches.

Uneven-Aged Stands.

The situation of a forest in reference to transportation facilities, the possibility of close utilization, and the rapidity of growth determine the method of management and consequently the character of the cutting.

Tracts so inaccessible that there is no present or prospective market for small material should be managed primarily for sawtimber, which can stand a higher cost of logging and transportation. In cutting old timber on tracts which are to be managed primarily for sawtimber, the trees should be cut to a diameter of not less than 18 inches breast high on good sites and 14 inches on poor

sites. But even in cutting to such limits considerable discretion should be used. A thrifty young, smooth-barked tree, with a long, straight stem, might well be held over for the second cutting, even if as large as 20 inches in diameter, since such a tree would undoubtedly be making a rapid growth. On the other hand, trees below these diameters, if short-bodied, crooked, and defective, or trees which are shading a thrifty group of young saplings, or crowding a group of poles, might well be cut, even if the profit in cutting them is very small. Thrifty young trees, the cutting of which would yield only a small profit, should be left if the cost of logging is low enough to permit it.

The utilization of large, old timber should be as clean as possible, but it will be impossible to use many of the old trees which are too defective for sawtimber. These can be left, since they will not only serve as seed trees, but may eventually be used for tannic extract stock. In localities where the market is better and where posts, ties, and extract stock can be sold, even if the local transportation must be done by flume or road, the forest can be left in much better condition for future earning value. It will be possible to cut out most of the old, defective trees and convert the seedling stand into a sprout stand, which will have a greater capacity for growth. Seedling chestnuts eight inches or less in diameter should not be cut, however, but should be left to replace exhausted stock at the second cutting. All other species which are mixed in with groups of chestnut, and which can be used, should be cut at the same time as the chestnut in order that the chestnut sprouts may have full light for their growth. When there is a market for poplar or pine pulpwood, seed trees of these species should be left, since they make a good mixture with the chestnut. Red maple and black gum, if taken for paper stock, should be cut to the smallest merchantable diameter. Seed trees of chestnut oak and red oak can be left, but Spanish oak and white oak should be cut to smallest merchantable size.

Timber which has a rate of growth as slow, or slower than that on second-quality sites, should be managed so as to secure even-aged sprout stands. This would apply not only to much of the timber on the south slopes, ridges, and upper north slopes of mountains in the eastern part of the State and the Cumberland plateau, but to chestnut stands as far west as Stewart and Hickman counties. The chestnut on poor sites is largely associated with chestnut oak, which

is also a vigorous sprouting species. The poorer the site, the less is the difference in the rate of growth between chestnut and chestnut oak, since chestnut oak is less affected by a poor condition than is chestnut. Managed as sprout forests, these sites can produce timber large enough for extract stock in a comparatively short time, while many trees will become large enough for ties and a few for poles. On the Cumberland tableland, where mine props are used, much of the small timber can be cut for this purpose. The production of larger timber for sawlogs is not advisable, since the growth of the trees becomes too slow after reaching a diameter of 14 to 16 inches. Stands should be cut close, but seedling chestnut 8 inches or less in diameter should be left in a first cutting in order that they may replace exhausted stumps and become old enough to seed. Seed trees of red oak, chestnut oak, and yellow pine should also be left.

When there is no market for tannic extract stock the timber on the ridges should be managed for tie production in sprout stands. It should be managed as seedling stands for sawtimber only where there is no possibility of marketing smaller material which can be grown from sprouts.

In slopes and hollows the rate of growth is usually equal to, or better than that on second-quality sites. On tracts at a distance from shipping points, chestnut should be managed only for sawtimber, poles, or ties, and old timber should be cut in the same general manner as on the ridges. Seedling reproduction should be encouraged. The old trees should be cut, as nearly as market conditions will permit to a minimum diameter of 20 inches for sawtimber, but to 14 inches for ties. All crooked and defective trees which can be used should be cut. As the quality of the soil improves, chestnut becomes relatively less valuable than some other species, such as popular and white pine, and these should be favored so as to have a mixed stand of chestnut and these species.

Near shipping points poles are relatively more valuable than sawtimber, and where there is a certain market for poles old timber should be cut to a diameter of 14 inches, and sprout reproduction, supplemented by seedlings, encouraged. However, it is always advisable to reserve a few large trees of poplar, white pine, red oak or ash.

EVEN-AGED STANDS.

There are in Tennessee probably more than 100,000 acres of even-aged, second-growth chestnut, either in pure stands or where chestnut forms more than one-half of the stand. These are largely sprout forests on old "coalings," which were made to supply charcoal with which to operate forges, furnaces, or smelters. A small number of these stands are in "deadenings," which were never cultivated or were cultivated only a few years. Few of them have resulted from lumberings, but as closer utilization becomes possible, lumbering will approximate clean cutting and even-aged stands of young growth will largely replace the uneven-aged forest. While these even-aged sprout stands give high yields of straight, clean-bodied timber, there is one drawback in their management which cannot be overlocked; that in order to obtain vigorous sprouts it is necessary to cut at the inconvenient seasons of winter, spring, or early summer. If the stumps are cut in autumn many will fail to sprout, and early summer cutting is also objectionable, because the bark from which the sprouts arise is easily separated from the stump, and is likely to be torn off during the lumbering operations.

In the management of even-aged stands yield tables, which show the amount of wood that can be cut at different ages, are necessary. Their chief value is to indicate the age at which stands that have different rates of growth may reach the period of maximum growth, or maturity, and should be cut. It is necessary to determine this age for each product into which the timber can be converted, since the age of maturity varies for various products. Yield tables can also be used for estimating the quantities of material which can be expected from the second-growth stands which will follow after the old timber is cut. In using yield tables to make such forecasts, however, it is necessary to make proper allowance when the mixture of other species differs from that allowed in the yield tables.

Under present conditions yield tables of this character can seldom be used in timber estimating, since they are constructed for dense, second-growth stands which have been uninjured by fire or cattle, and are applicable only to such conditions. The yield of most second-growth stands is much below that of the tables. The tables, however, serve to indicate the large yields which can be obtained by protecting clean-cut land and securing dense, even-aged stands.

Cordwood—Chestnut cordwood is chiefly used for tannic acid

extract stock, while a relatively small amount is used for fuel. Consequently the dimensions for wood used in constructing the cordwood yield tables conform to the manufacturers' specifications for the tannic acid extract wood. The wood in Tennessee is used with the bark attached. Split-stem wood is most desired, but a small proportion of round wood is taken to a diameter of three inches if straight and free from large knots. This permits the use of much branch wood and the cutting of trees as small as five inches in diameter. Wood with large knots, as from the crowns of old trees, is rejected by the manufacturers. If trees less than 25 inches in diameter are well handled the tops can be completely worked up, except for the crooked parts of the limbs and the portions having a diameter less than 3 inches.

Table 4 gives the yield in long cords (160 cu. ft.) per acre of chestnut stands at different ages, and of different qualities of growth. In the second column under each quality is given the growth in cords during each decade. The maximum growth in the first quality site takes place during the fifth decade; in the second and third during the sixth decade.

The first and second quality stands contain about 10 per cent of the species other than chestnut, and the third about 15 per cent, which is not included in the tables. In the first and second qualities the associated species are chiefly yellow poplar, red oak and white pine. In the third it is largely chestnut oak, the wood of which to a limited extent is also used for extract stock.

Table 4—Yield of long cords per acre in wood and bark of pure stands of chestnut at various ages on different quality sites. Trees taken to a minimum diameter of 5 inches, and split as required in specifications for tannic extract wood.

Age—Years	First Quality. Yield per acre	First Quality. Growth during preced. decade	Second Quality. Yield per acre	Second Quality. Growth during preced. decade	Third Quality. Yield per acre	Third Quality. Growth during preced. decade
	LONG CORDS.					
15	3.8	....	1.0	....	....	....
20	7.9	7.0	3.9	3.5	....	....
25	12.6	....	7.6	....	3.3	....
30	18.4	10.5	12.0	8.1	6.1	6.0
35	25.3	....	17.1	....	9.1	....
40	33.1	14.7	22.7	10.7	12.3	6.2
45	45.1	....	28.9	....	15.6	....
50	58.4	25.3	36.0	13.3	19.2	6.9
55	70.2	....	43.6	....	22.8	....
60	78.3	19.9	50.4	14.4	26.7	7.5
65	83.1	....	55.5	....	30.8	....
70	86.8	8.5	59.8	9.4	31.6	4.9

Table 5 gives the average annual growth in long cords per acre for stands on different quality sites at various ages. In stands of the first quality the average annual yield of tannic acid cordwood is greatest about the sixtieth year; in those of the second and third qualities, the average annual yield is greatest about the sixty-fifth year. Since the average annual yield is less, both before and after these ages, they represent maturity for cordwood stands, which therefore should be cut at 60 or 65 years, according to site.

Table 5—Average annual yield in long cords per acre of pure stands of chestnut at various ages on different quality sites.

Age of Stand,	YIELD First Quality.	Second Quality.	Third Quality.
Years.	LONG CORDS.		
20	0.4	0.2	...
25	0.5	0.3	...
30	0.6	0.4	0.2
35	0.7	0.55	0.3
40	0.8	0.65	0.3
45	1.0	0.6	0.3
50	1.2	0.7	0.4
55	1.3	0.8	0.4
60	1.3	0.84	0.4
65	1.3	0.85	0.47
70	1.2	0.85	0.45

Cordwood stands should be cut clean, except for seedlings or seedling sprouts of sapling size, which can form a part of the succeeding crop. The best quality sites can probably be utilized more profitably for growing larger timber for ties, poles, and sawlogs. The poorer sites can be most advantageously used for cordwood on account of the generally poor growing conditions.

Mixed stands which contain only a small proportion of chestnut cannot be profitably managed exclusively for extract cordwood, unless other species can be cut simultaneously with the chestnut for cordwood, or unless the chestnut occurs in large, pure groups scattered through the forest. This would apply to the larger portion of the mixed oak and chestnut forest of the Highland Rim and farther west. If single, scattered trees of chestnut are cut in such mixed stands there will frequently be insufficient light for the growth of the sprouts, and this would ultimately result in a great decrease in the proportion of chestnut in the forest.

Many second-growth stands on good soils contain a variable proportion of yellow poplar, ash, white pine, and red oak, which are too small to be very valuable for sawtimber at the age when chestnut is best suited for cordwood, or even for ties or poles. Well-formed trees of these species, particularly the ones with slender stems, might be left. They would interfere very little with the reproduction of the chestnut sprouts, and would increase rapidly in diameter. They would make extremely large and valuable sawlogs by the time the next stand of chestnut sprouts was ready to be cut.

Pole Ties—At the present time chestnut ties are not cut extensively in Tennessee, oak timber suitable for ties being still abundant and comparatively cheap. The use of chestnut ties, however, is increasing so rapidly that chestnut can be regarded as a standard tie wood in Tennessee, as it has already become in many States farther north. In Eastern Tennessee chestnut is cut only into pole ties 7 by 9 inches by 8.5 feet long. Since the ties are hewed and the logs are rarely split, there is considerable waste in the larger logs from the lower part of trees more than 16 inches in diameter. There is also a large waste in small trees in the unused length of stem in the top. (See Table 6.) A 7 by 9-inch tie, 8.5 feet long, contains 3.7 cubic feet of solid wood if it is sawed. The hewed ties contain more wood than this, probably as much as 4.5 cubic feet, on an average. Trees which yield ties with the least waste are those from 14 to 16 inches in diameter. In trees below 13 inches, and in those above

18 inches, more than twice the volume called for in the specifications is consumed. In trees below 15 inches in diameter the waste largely lies in the unused upper length of the stem; in trees above 16 inches, the waste is in the diameter in excess of that called for in the specifications.

Table 6—Cubic contents of trees of various diameters, cut to a 4-inch top diameter, average number of ties per tree, and average waste in clear length.

Diameter, breast-high,	Total volume of stem,	Average ties per tree	Actual contents of stem wood to produce each tie*	Total length of clear stem,	Length of clear stem not used,
inches	cubic ft.	No.	Cubic ft.	ft.	feet
10	9.60	1.0	9.6	41	32
11	12.3	1.4	8.8	42	30
12	16.8	2.1	8.0	44	26
13	22.6	3.1	7.3	47	20
14	28.4	4.0	7.1	50	16
15	35.0	5.0	7.0	56	13
16	38.0	5.5	6.9	57	10
17	43.9	6.1	7.2	60	8
18	49.3	6.4	7.7	61	6
19	56.8	6.6	8.6	61	4
20	63.9	6.8	9.4	61	3

Note—*Specifications require four cubic feet.

Table 7 gives the number of pole ties 8.5 feet long by 7 by 9 inches wide, which can be cut from trees of different heights and diameters. The number of oak and locust ties in trees of different diameters are shown in the last column. Both the oak and locust yield fewer ties than chestnut from trees of the same diameter on account of their thicker bark and shorter, more crooked, and more tapering stems. The proportion of oak and locust ties in the stands is less than 33 per cent.

Table 7—Tie volume table, giving average number of pole ties (8.5 feet long by 7 by 9 inches) in trees of different heights and diameters.

D. B. H., Inches	Chestnut. Height—Feet. 50	60	70	80	90	100	110	Oaks and Locust All Heights
	Number of Ties Per Tree.							
10	....	0.7	0.9	1.1	1.2	1.2	1.2	....
11	0.8	1.1	1.3	1.5	1.7	1.8	1.9	0.7
12	1.3	1.7	2.0	2.3	2.5	2.7	2.8	1.4
13	1.8	2.3	2.7	3.1	3.5	3.7	3.8	2.0
14	2.3	2.9	3.4	3.9	4.3	4.5	4.7	2.8
15	2.7	3.4	4.1	4.7	5.1	5.4	5.5	3.7
16	2.7	3.5	4.3	5.0	5.6	6.0	6.3	4.0
17	2.8	3.7	4.6	5.4	6.0	6.4	6.6	4.3
18	2.8	3.8	4.8	5.7	6.3	6.7	6.9	5.0
19	2.9	3.9	4.9	5.8	6.5	6.9	7.2	5.3
20	2.9	4.1	5.1	5.9	6.6	7.1	7.4	5.7

The number of ties which can be cut from a stand increases with its age up to a certain limit, after which there is no additional increase, or only a slight one. The greatest annual yield of ties from a first quality site is obtained when the stand is about 60 years old. On second and third quality sites the maximum annual yield is not obtained until the stands are at least 70 years old, because of the longer time required for the trees to reach tie size. By cutting the entire stand clear, a yield of more than 600 No. 1 ties per acre can be obtained from 60-year-old stands of first quality; a yield of 364 ties at the same age from stands of the second quality, and more than 200 ties from stands of the third quality. Table 8 gives the yield of pole ties which can be obtained per acre from unthinned stands of different qualities at different ages. While this table shows the yield which can reasonably be expected from one clear cutting of dense stands, it by no means gives the maximum yield which can be obtained at intervals in two or three cuttings, or from thinned stands.

Table 8—Tie yield table. Yield of pole ties per acre in unthinned stands of chestnut (less than 33 per cent other species) at various ages. (Pole ties 7 by 9 inches by 8.5 feet long).

	Quality I.		Quality II.		Quality III.	
	Total Ties	Average annual yield	Total Ties	Average annual yield	Total Ties	Average annual yield
Years.	Number of Ties.					
25	39	....	....	....	....	....
30	99	3.3	18	....	....	....
35	176	....	60	....	9	....
40	269	6.7	107	2.7	51	1.2
45	359	....	167	....	98	....
50	471	9.4	231	4.6	145	2.9
55	565	....	299	....	184	....
60	619	10.3	364	6.0	217	3.6
65	659	....	406	....	244	....
70	685	9.8	433	6.2	265	3.9

Unthinned second-growth stands should not be cut clean for ties, since the ultimate yield of ties from such a stand can be increased by cutting only trees which have reached a diameter large enough to give a high yield of ties per tree. Cutting in stands within easy hauling distance of a shipping point should not take place until the largest trees are 16 inches in diameter, breast high, at which time all trees of 15 and 16 inches should be removed. Cuttings can be repeated at intervals of a few years, removing each time only the trees of these diameters. This assures an average yield of five ties per tree in quality 1; more than three in quality 2; and nearly three in quality 3. When the third cutting is made it is desirable to cut clean in order to secure an approximately even-aged stand of sprouts. If cutting is continued for too long, not only is the stand converted into an uneven-aged one, but the sprouts from many of the chestnut stumps die on account of the shade, resulting in a large increase in the young stand of oak, maple, beech, sourwood, and other tolerant species which seed abundantly. While the trees removed should be as evenly distributed as their sizes will permit, it is desirable to retain the trees of seedling origin until the last cutting. In making cuttings of this kind great care must be exercised in the last cuttings not to break down the sprouts which have already appeared.

When stands are situated at a distance from transportation

facilities, and it is impossible to make several cuttings at short intervals, cuttings need not begin until the largest trees are 17 inches in diameter, and all trees can be cut to a diameter of 13 inches. This would make possible a heavy cutting and still leave a large number of very slender trees less than 13 inches in diameter, most of which would become merchantable within 15 years when the stand could be cut clean.

Young forests of poles, 12 inches or less in diameter, on farms or near a market, should be treated as cordwood stands for extract wood. If correctly done, the thinnings will greatly increase the yield of ties over that given in Table 7, and enable most of the trees to be simultaneously developed to tie size. They can then be removed in two cuttings made at such short intervals as to amount practically to a clean cutting.

Poles—There is a regular market for poles in Tennessee, and this is one of the most profitable forms in which small chestnut timber can be marketed. Poles are best produced in sprout stands in qualities one and two; that is, in the mountain coves and on other soils of good quality. On the poor sites the stems of the trees are apt to be crooked, and have too little taper to meet pole specifications for the larger sizes. Specifications are more easily complied with when the growth is very thrifty. Pole production should be attempted only when logging is easy and transportation by railroads or streams is close at hand. The cost of handling large and long poles is so great that inexperienced contractors frequently fail to make a profit in handling them. Stands intended for poles should be thinned in the manner described for ties. Tall, straight, and sound poles, many of which will have approximately the taper called for in the specifications of the American Telephone and Telegraph Company, can be grown in this way. Table 9 gives the specifications for poles as required by this company. These are approximately the same as required by other users of poles.

Table 9—Specifications for poles. American Telephone and Telegraph Company. Minimum dimensions for peeled poles.

MINIMUM DIMENSIONS OF PEELED POLES.

Length of Poles,	50, 60, 70 or 80-Wire Line		Heavy Trunk Line		Light Trunk Line		Light Line		Branch Line	
	Circumf'r'nc		Circumf'r'nc		Circumf'r'nc		Circumf'r'nc		Circumf'r'nc	
	6 ft. from top	6 ft. from butt,	6 ft. from top,	6 ft. from butt,	6 ft. from top,	6 ft. from butt,	6 ft. from top	6 ft. from butt	6 ft. from top,	butt
feet	inchs.	inchs..	inchs..	inchs.	inchs..	inchs	inchs.	inchs..	inchs.	inchs.
20	..	..	..	..	..	..	..	..	15½	23
22	..	..	..	..	..	..	..	..	15½	24
25	..	..	..	..	20	30	20	27	15½	26
30	24	40	22	36	20	33	20	31	15½	29
35	24	43	22	40	20	36	20	35	20	34
40	24	45	22	43	20	40	20	39	20	38
45	24	48	22	47	20	43	20	43	20	42
50	24	51	22	50	20	46	20	46	20	46
55	22	54	22	53	20	49	..	..	..	..
60	22	57	22	56	..	..	..	..	..	..
65	22	60	22	59	..	..	..	..	..	..
70	22	63	22	62	..	..	..	..	..	..
75	22	66	22	65	..	..	..	..	..	..
80	22	70	22	69	..	..	..	..	..	..
85	22	73	22	72	..	..	..	..	..	..
90	22	76	22	75	..	..	..	..	..	..

Sawtimber—Second-growth sprout stands will seldom give any heavier yield of large saw timber than seedlings of the same age, since the rate of growth of sprouts eventually declines and becomes less than that of seedlings. Sprout stands are best suited to the production of smaller stems than those required for the best saw-logs. Sprout timber, however, can very well be sawed into ties, and, in addition to the ties, several boards can be obtained from the larger logs.

Table 10 shows the yield in board feet, both on the basis of the Doyle-Scribner log scale and on the basis of the actual mill cut, which can be obtained from stands of different qualities at different ages. It also gives the supplemental yield in cords of extract wood from tops and from trees below 10 inches in diameter, and the total value of the stands at different ages. These tables are based on 132 sample plots.

QUALITY I.

Table 10(*a*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Yield Per Acre of Trees 10 Inches and Over.			Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord.
Age Years	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
25	900	2,000	16.0	20.00
30	2,100	4,500	15.3	24.30
35	3,800	7,600	13.5	28.70
40	5,800	10,900	12.3	33.10
45	8,300	14,900	11.0	40.80
50	11,100	19,300	9.5	46.10
55	14,400	24,300	8.0	56.80
60	18,100	29,900	7.0	66.80

QUALITY II.

Table 10(*b*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Yield Per Acre of Trees 10 Inches and Over.			Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord.
Age Years	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
30	200	500	17.3	18.30
35	1,200	2,600	16.5	21.70
40	2,300	4,800	15.5	25.10
45	3,700	7,400	14.0	28.80
50	5,400	10,200	13.0	33.40
55	7,300	13,300	11.5	38.10
60	9,400	16,700	10.0	43.40

QUALITY III.

Table 10(*c*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Yield Per Acre of Trees 10 Inches and Over.			Yield of trees from 5 in. to 10 in and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord
Age Years	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
40	400	1,000	17.5	19.50
45	1,300	2,800	18.0	23.60
50	2,400	4,900	17.0	26.80
55	3,600	7,200	15.3	29.90
60	5,000	9,600	13.5	32.70

Relation of Board Feet to Cubic Feet and Cords.

Table 11 shows the number of board feet (scaled by the Doyle-Scribner rule) to 1 cubic foot and to 1 cord of merchantable volume for trees of different diameters. It is evident from this table that as the diameters of the trees increase a greater number of board feet can be obtained for every cubic foot and consequently for every cord of merchantable volume. Thus, only 3 board feet can be obtained per cubic foot for trees 12 inches in diameter, while from trees 30 inches in diameter 5.2 board feet can be obtained for every cubic foot. In addition the lumber from the larger trees is of better quality than from the smaller ones. This means that, in many instances, it is more profitable to convert the smaller trees into extract wood than into lumber. For instance, if the stumpage price of lumber is $2 per thousand board feet and of extract wood $1 per cord, the same amount of material from 12-inch trees would be worth $1 if sold as extract wood and 63 cents if sold as lumber. On the other hand, from 30-inch trees the same amount of material would be worth $1 if sold as extract wood and $1.11 if sold as lumber. At these stumpage prices the timber is worth more as extract wood from trees up to 24 inches in diameter, and more as lumber from larger trees. If the actual mill cut, which overruns the values given by the Doyle-Scribner rule, were used as a basis, the number of board feet per cord would be greater, and the value of the trees for lumber correspondingly increased. In these calculations the slabs from the saw logs are given no value, and tops, which would not be merchantable as sawlogs, are excluded.

Table 11—Board feet (Doyle-Scribner rule) per cubic foot and per cord for trees of different diameters.

Diameter, breast-high.	Board feet per cubic foot of merchantable volume.	Board feet per cord of merchantable volume.	Value of a cord at $2 per thousand board ft.
Inches	Board feet	Board feet	Dollars
12	3.0	313	$0.63
13	3.1	322	0.64
14	3.2	333	0.67
15	3.4	342	0.68
16	3.5	364	0.73
17	3.6	376	0.75
18	3.8	386	0.77
19	4.0	407	0.81
20	4.2	429	0.86
21	4.3	448	0.90
22	4.4	461	0.92
23	4.6	472	0.94
24	4.8	493	0.99
25	4.9	515	1.03
26	5.0	526	1.05
27	5.0	535	1.07
28	5.1	538	1.08
29	5.2	546	1.09
30	5.2	556	1.11

SUMMARY.

Chestnut is one of the most widely distributed trees of Tennessee, and the most important tree in the mountains of the eastern portion of the State, occupying large areas of land which have a low agricultural value.

The great number of uses to which the wood is put enables extremely close utilization not only of all portions of sound trees, including limbs and bark, but also a large amount of more or less defective wood. Small trees are used for poles, posts, and ties; large, sound trees for lumber and shingles. Tops and low-grade wood are used for tannic extract, fuel wood, and paper pulp stock.

Chestnut is not only a tree of rapid growth, but reproduces easily from seed and vigorous and abundant sprouts even from large old stumps. It forms pure stands or large, pure groups over extensive areas, permitting cheap utilization, and makes heavy yields at an early age. Under average conditions of growth, yields of 40 cords of tannic acid extract wood; or more than 300 No. 1 (7-in. by 9-in. by 8.5-ft.) ties; or 90 large poles; or 10,000 board feet of lumber, can be obtained per acre within 50 years from unthinned but protected second-growth stands. When logged for poles, lumber, or ties, about 13 cords of extract wood can also be obtained. If the

stands are thinned, the yield can probably be doubled in the same time. For these reasons chestnut is one of the most promising trees for forest management.

To obtain the best yields from chestnut stands, protection from fire is absolutely necessary, because the trees, and particularly the young trees, are extremely sensitive to fire injury. It is also necessary to protect young stands from cattle, since considerable damage results from browsing the foliage and young shoots.

In order to develop the maximum producing value of the forest, different methods of cutting should be used in different types and classes of forest. Large sawtimber should be grown only in the coves and on other good situations. Inaccessible old stands which can be used only for lumber should be cut to a relatively low diameter limit (16 inches), the large, unsound trees being left for possible future cutting for extract wood and for seed trees, and the smaller trees for increase in growth. Seedling stands are desirable and would be encouraged by this method of cutting. When extract wood can be sold, old stands on good soils should be cut to about the same diameter limit, if the production of sawtimber is the chief object of management, but all of the large, old defective trees should be removed for extract wood. On the ridges old timber should be cut for extract wood to a diameter of 8 or 10 inches, with the object of obtaining even-aged sprout stands which on such sites will give in a short rotation a higher yield than seedling stands, because of the more rapid growth of sprouts than seedlings when young. When there is no market for extract wood, and only sawtimber can be exploited, chestnut on the ridges can be cut to a diameter of 14 inches breast high, which would permit a second profitable cutting to be made within 15 years.

Even-aged, second-growth sprout and seedling stands, such as occur on farms, and on old charcoal cuttings, should be cut clean in not more than three cuttings, made at intervals of from 5 to 10 years, in order to replace the stands by even-aged sprout stands. The yield of such stands, in ties, poles, and lumber, and even in cordwood, can be greatly increased by thinning the stands while young, at regular intervals, removing the large crooked and forked trees and the tall, slender trees with narrow or one-sided crowns, and leaving the larger best-formed trees for the mature stand.

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